Power Generation by Exhaust Gases On Diesel Engine

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Abstract-*In this research work the modification of stationary diesel engine for producing power using turbine. Nowadays in automobile field many new innovating concepts are being developed. We are using the power from vehicle exhaust to generate the electricity which can be stored in battery for the later consumption. In this project, we are demonstrating a concept of generating power in a stationary single cylinder diesel engine by the usage of turbines. Here we are placing a turbine in the path of exhaust in the silencer. An engine is also placed in the chassis of the vehicle. The turbine is connected to a dynamo, which is used to generate power. Depending upon the airflow the turbine will start rotating, and then the dynamo will also starts to rotate. A dynamo is a device which is used to convert the kinetic energy into electrical energy. The generated power is stored to the battery. It can be stored in the battery after rectification. The rectified voltage can be inverted and can be used in various forms of utilities.*

Keywords*: Diesel engine, dynamo, exhaust and turbine, revolutions per minute (r. p. m).*

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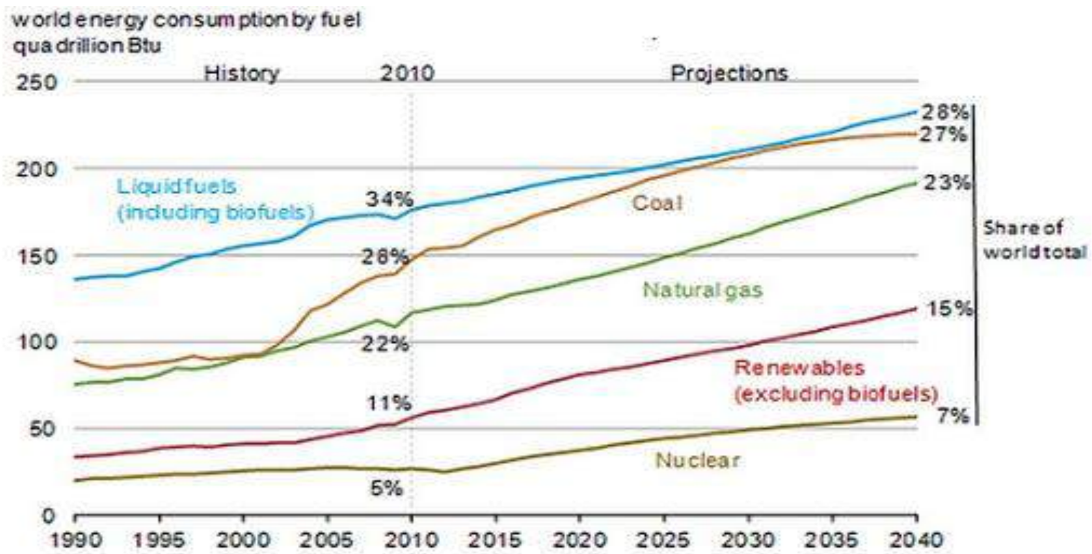
1. INTRODUCTION

In recent years the scientific and public awareness on environmental and energy issues has brought in major interests to the research of advanced technologies particularly in highly efficient internal combustion engines. Viewing from the socio-economic perspective, as the level of energy consumption is directly proportional to the economic development and total number of population in a country, the growing rate of population in the world today indicates that the energy demand is likely to increase.Substantial thermal energy is available from the exhaust gas in modern automotive engines. Two-thirds of the energy from combustion in a vehicle is lost as waste heat, of which 40% is in the form of hot exhaust gas. The latest developments and technologies on waste heat recovery of exhaust gas from internal combustion engines (ICE). These include thermoelectric generators (TEG), Organic Rankine cycle (ORC), six-stroke cycle IC engine and new developments on turbocharger technology. Being one of the promising new devices for an automotive waste heat recovery, thermoelectric generators (TEG) will become one of the most important and outstanding devices in the future.

A thermoelectric power generator is a solid state device that provides direct energy conversion from thermal energy (heat) due to a temperature gradient into electrical energy based on "Seebeck effect". The thermoelectric power cycle, charge carriers (electrons) serving as the working fluid, follows the fundamental laws of thermodynamics and intimately resembles the power cycle of a conventional heat engine[2,3]. One potential solution is the usage of the exhaust waste heat of combustion engines. This is possible by the waste heat recovery using thermoelectric generator. Tthermoelectric generator converts the temperature gradient into useful voltage that can used for providing power for auxiliary systems such as air conditioner and minor car electronics. Even it can reduce the size of the alternator that consumes shaft power. If approximately 6% of exhaust heat could be converted into electrical power, it will save approximately same quantity of driving energy. It will be possible to reduce fuel also. For example, the heat of the car's exhaust can be used to warm the engine coolant to keep the engine running warm, even when the motor has been turned off for a significant length of time. A vehicle's exhaust can actually be used to generate electricity. Although these technologies can be used in any car, truck or SUV with an internal combustion engine, they're particularly important to hybrid vehicles, which need to produce maximum fuel efficiency (Graph.5)



Graph.1.World fuel consumption levels from 1990-2040

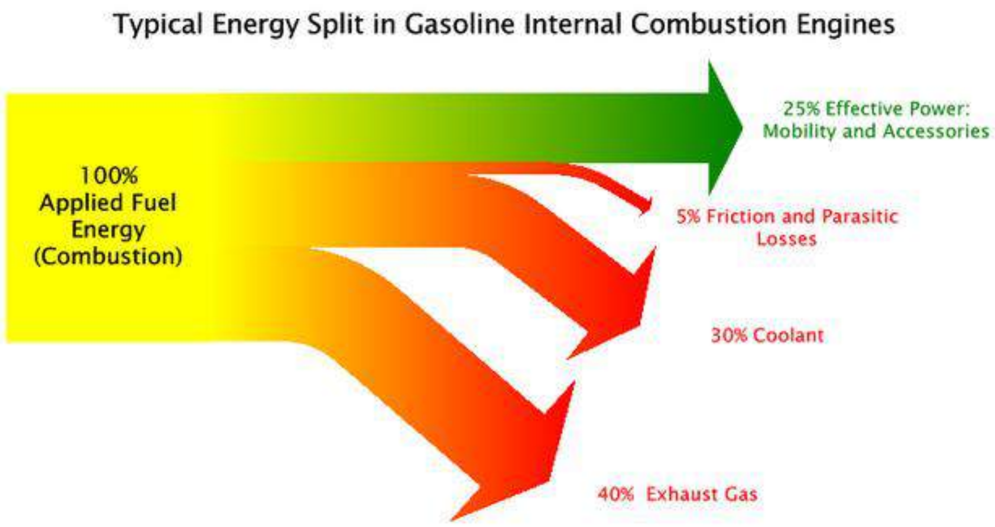


Fig.1. Engine temperature losses

About 35% of the fuel is converted to useful crankshaft work, and about 30% energy is expelled with the exhaust. This leaves about one-third of the total energy that must be transmitted from the enclosed cylinder through the cylinder walls and head to the surrounding atmosphere.

2. APPLICATIONS

Power generation using vehicle exhaust gas system can be used in most of the Two wheelers and Four wheelers

ISSN: 0975-5662, Dec, 2015 www.ijrct.org

- It is applicable for all stationary and moving vehicles.
- It is applicable for all Automobiles.
- The generating power is applicable for house hold uses.
- Auxiliary uses like indicators, horn etc.
- No problems of discharge in the batteries.

3. WORKING AND DESIGN

Power is generated by using automobile exhaust gas is very simple and easy non-conventional process. Energy generation using vehicle silencer needs no fuel input power to generate the output of the electrical power. This project using simple mechanism same as wind energy power generation. For this project the main Working Principle is Conversion of the forced kinetic energy into electrical energy. In this the exhaust gases released from the automobile Silencer is used to rotate the turbine (fan blades) by arranging it is very conveniently. The nozzle is attached to the silencer is used to proper flow of exhaust gases with high velocity and steady flow with uniform direction torotate the turbine. The dynamo attached to the turbine with shaft is used to convert the forced kinetic energy(K.E) into electrical energy(E.E) is by rotating dynamo[2,3].

The main components used in this process is

- Turbine
- Dynamo
- Battery
- Nozzle

TURBINE-A steam turbine is a mechanical device that extracts thermal energy from pressurized steam, and converts it into rotary motion. It has almost completely replaced the reciprocating piston steam engine primarily because of its greater thermal efficiency and higher power-to-weight ratio. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator – about 90% of all electricity generation in the United States is by use of steam turbines[2]. The steam turbine is a form of heat engine that derives much of its improvement in thermodynamic efficiency through the use of multiple stages in the expansion of the steam, which results in a closer approach to the ideal reversible process.

- It is a simple non – conventional energy process.
- This generating power can reduce the need of power.
- To generate the power no need of fuel input.

Fig.2.Turbine

DYNAMO-Dynamo is an electrical generator. This dynamo produces direct current with the use of a commutator. Dynamo were the first generator capable of the power industries. The dynamo uses rotating coils of wire and magnetic fields to convert mechanical rotation into a pulsing direct electric current. A dynamo machine consists of a stationary structure, called the stator, which provides a constant magnetic field, and a set of rotating windings called the armature which turn within that field. On small machines the constant magnetic field may be provided by one or more permanent magnets, larger machines have the constant magnetic field provided by one or more electromagnets, which are usually called field coils.

Fig.3.Dynamo

NOZZZLE- Jet nozzles are also use in large rooms where the distribution of air via ceiling diffusers is not possible or not practical. When the temperature difference between the supply air and the room air changes, the supply air stream is deflected upwards, to supply warm air, or downwards, to supply cold air. Nozzles can be described as *convergent* or *divergent* (expanding from a smaller diameter to a larger one). A de Laval nozzle has a convergent section followed by a divergent section. and is often called a convergent-divergent nozzle.

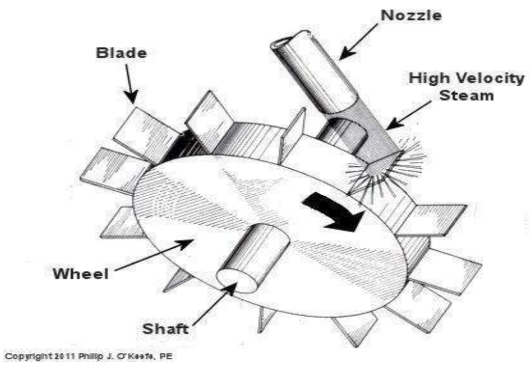


Fig.4. Nozzle and Turbine

BATTERY- It is a device user to store the power. The power is stored in the form of DC current only. There are many types of batteries are used Lead acid , lithium fluoride and in this work 8Amp current and 12 voltage specification is used.

Fig.6. Battery

3.1. Power Generation

In this the exhaust gases released from the automobile Silencer is used to rotate the turbine (fan blades) by arranging it is very conveniently. The nozzle is attached to the silencer is used to proper flow of exhaust gases with high velocity and steady flow with uniform direction to rotate the turbine .the dynamo attached to the turbine with shaft is used to convert the forced kinetic energy(K.E) into electrical energy(E.E) is by rotating dynamo[1,3,4].

4. FORULAS AND CALCULATIONS

The main calculations include in this process is,

- Engine Exhaust Flow Rate Calculations
- Brake Power Calculations on Engine

4.1 **Engine Exhaust Flow Rate Calculations**: Exhaust flow rate [5,6] may be calculated using the following formula. Exhaust temperature and intake airflow rate must be determined to calculate the exhaust flow rate. Exhaust temperature and manufacturers maximum back pressure may be approximated using the Table.1.

$$\frac{(\text{Exhaust Temp .(°F)} + 460)}{540} * \text{Intake Airflow} = \text{Exhaust}$$

Engine Airflow Calculations CFM intake rate is available from the engine manufacturer. If CFM specifications are not available, use the volumetric efficiency calculation. A simple calculation for cfm is to multiple the horsepower of your engine by 2.

$$\frac{\text{Engine Size (CID) x RPM 3456}}{3456} \text{X Volumetric Efficiency}$$

= Intake Airflow (CFM)

2-Cycle Engine Airflow Calculation:

$$\frac{\text{Engine Size (CID) x RPM 3456}}{1728} \text{X Volumetric Efficiency}$$

= Intake Airflow ;

Volumetric Efficiency is

4 Cycle GAS Engine Naturally Aspirated = 0 .70 - 0.80; 2 and 4 Cycle DIESEL Engine Naturally Aspirated= 0.90 Turbo* = 1.50 - 3.00

4.2 Brake Power Calculations On Engine:

Brake Power: It is the delivery power of the engine It is the only power used by the engine.

$$\text{B.P} = \frac{2\pi r n}{60000}$$

ISSN: 0975-5662, Dec, 2015 www.ijrct.org

And also the torque and the angular speed measurement of engine are involved in measurement of break power. Dynamometer is used for torque measurement. The rotor of the engine which is under state is connected to stator. Rotor moves through distance 2πr against force F. Hence work done is W=2 πrF.

4.3. Power generation by exhaust gases:

Power is generated by using automobile exhaust gas is calculated as in sample calculations by(Table.2),

$$B.P = \frac{W*\pi dN}{60000}$$

$$= \frac{500*\pi*0.0875*1500}{60000} = 3.43\ KW$$

$$\frac{1000*\pi*0.0875*1500}{60000} = 6.87\ KW$$

Exhaust flow calculation:

$$\frac{\text{Engine Size (CID) x RPM 3456}}{3456} \text{X Volumetric Efficiency}$$

= Intake Airflow

$$\frac{0.0875*0.11*1500*3456}{3456} \text{ X } 0.75 = 10.82$$

$$\frac{(\text{Exhaust Temp .(°F)} + 460)}{540} \text{*Intake Airflow (Cfm)}$$

=Exhaust Flow

$$\frac{1000+460}{540} \text{ X } 10.82 = 29.25\ m/s.$$

B.P of dynamo:

$$B.P = \frac{15*\pi*0.22*600}{60000} = 10\ W$$

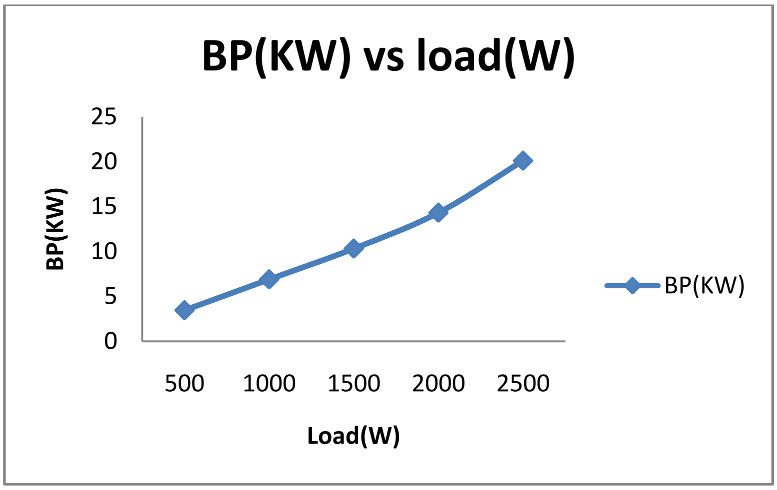
Table.1. Exhaust temperature and manufacturers maximum back pressure

S.No	Engine	Temperature	Backpressure
1	Diesel 2-Cycle Naturally Aspirated	900ºF	4" Hg
2	Diesel 2-Cycle Turbo	750ºF	3" Hg
3	Diesel 4-Cycle Naturally Aspirated	1000ºF	3"Hg
4	Diesel 4-Cycle Turbo	900ºF	3" Hg
5	Gasoline (All types)	1200ºF	4" Hg

Table.2. Power is generated by using automobile exhaust gas calculated at constant engine speed 0f 1500 r. p. m

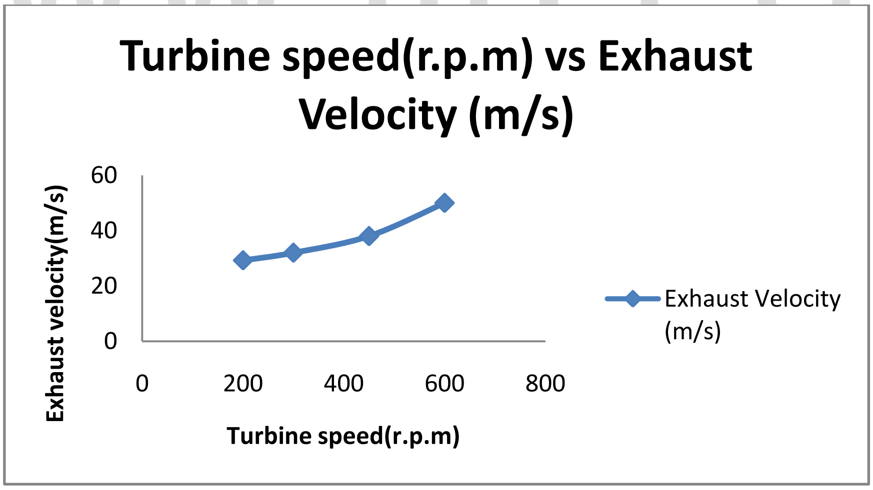
S.No	Load on Engine (W)	B.P of Engine (KW)	Speed of Turbine(r.p.m)	Exhaust Velocity (m/s)	Load on Turbine (W)	B.P of Exhaust gas (W)	Power generation Voltage(v)
1	500	3.43	600	38	12	9	24
2	1000	6.87	450	32	15	7.7	18
3	1500	10.30	300	29.5	24	7	14

5. RESULTS AND DISCUSSION



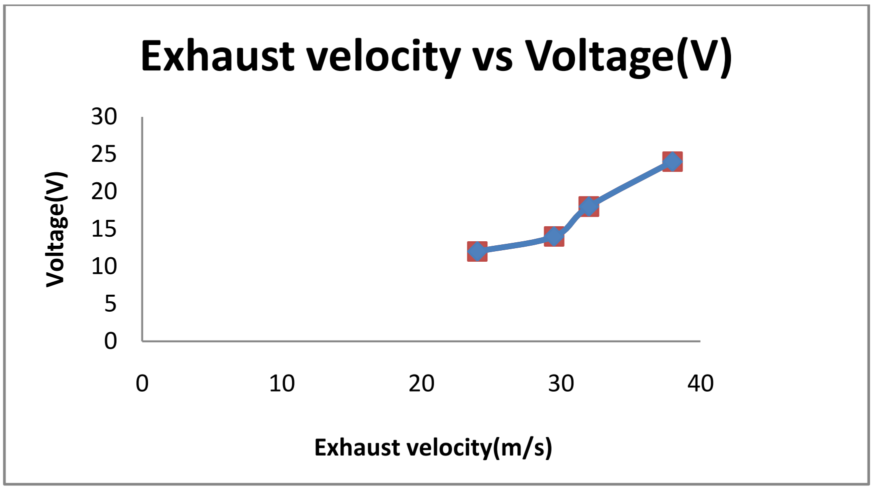
Graph.2.Plotted for Break power (KW) of engine to Load on Engine (W)

From the graph.2, the highest break power value (10.30KW) is obtained at the load 1500 watts at the constant engine speed is 1500 revolutions per minute (r.p.m).



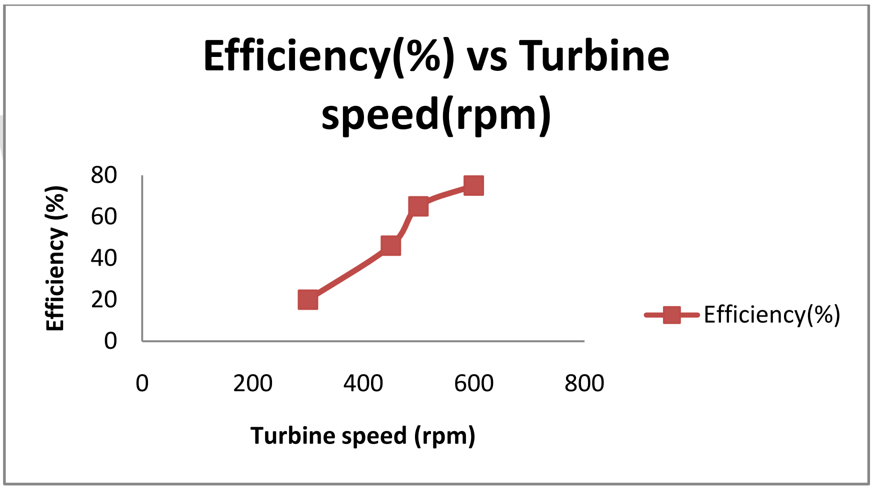
Graph.3.Plotted for turbine speed (r. p. m) to exhaust velocity (m/s)

From the graph.3, the turbine speed at the 600 r. p. m the exhaust velocity is 50m/s at the constant engine speed is 1500 revolutions per minute (r. p. m).



Graph.4. Plotted for voltage (V) generated from the exhaust velocity (m/s)

From the graph.4, it is observed that the maximum voltage (24 volts) is obtained at exhaust velocity 38 m/s at the engine speed 1500 r. p. m.



Graph.5. Plotted for efficiency to the turbine speed (r. p. m)

6. CONCLUSION

From the study, it has been identified that there are large potentials of energy savings through the use of waste heat recovery technologies. Waste heat recovery entails capturing and reusing the waste heat from internal combustion engine and using it for heating or generating mechanical or electrical work[7,8,9]. It would also help to recognize the improvement in performance and emissions of the engine if these technologies were adopted by the automotive manufacturers.

The study also identified the potentials of the technologies when incorporated with other devices to maximize potential energy efficiency of the vehicles[10]. The project carried out by us made an impressing task in the field of mechanical department. It is used for to produce the current in vehicle exhaust unit.

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